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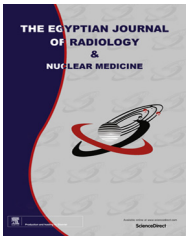

ORIGINAL ARTICLE

Utility of Multidetector Computed Tomography Angiography in evaluation of post traumatic neglected vascular injuries of the upper extremity

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KEYWORDS

MDCTA;
Neglected trauma to upper extremity;
Vascular trauma;
Arteries;
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Abstract *Background:* Vascular injuries of the upper limb are rare, and CT angiography (CTA) may be performed to assess vascular complications in neglected trauma patients.
Objectives: The aim of this study was to evaluate the role of CTA in evaluation of neglected vascular injuries.
Subjects & methods: This prospective study included 20 patients with previous trauma history, with clinically suspected vascular lesion. CTA was done for all patients followed by surgical treatment.
Results: CTA detects pseudoaneurysm in 11 (55%) patients, stenosis in 5 (25%) patients, total occlusion in 2 (10%) patients, and arteriovenous fistula (AVF) in 2 (10%) patients. One patient (5%) had metallic artifact that alters image interpretation. The accuracy of CTA in detecting vascular lesion in the examined patients was 95% with sensitivity and specificity of 95% and 100%, respectively.
Conclusions: MDCT angiography is highly accurate initial noninvasive diagnostic tool for the evaluation of vascular abnormalities of the upper extremity arterial system in patients with suspected neglected extremity trauma. Limitation of CTA examination was the presence of metallic artifact adjacent to the examined arteries.

1. Introduction

Trauma is a great public health dilemma in developing and developed countries and frequently involves young people. Among different kinds of trauma, vascular injuries of the extremities need special consideration because they can be threatening to limb and life. Although the rate of successful management of these injuries has been increased owing to proper pre hospital care, early referral of patients to specialized trauma centers, and proper surgical interventions, these injuries remain a challenging problem, especially in developing countries (1,2).

Traumatic injuries to the axillary and brachial arteries remain rare, representing 15–20% of arterial injuries to the upper extremity (3). Approximately 6% of these injuries are attributable to blunt trauma, with the majority occurring

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fooling fracture-dislocations. Less than 1% of vascular injuries to the upper extremity are associated with a traumatic dislocation alone (4).

Late sequel of untreated vascular injuries includes arterial occlusion, pseudoaneurysm, and arteriovenous fistula (5). The diagnosis of a vascular injury begins with the physical examination. Clinical signs of arterial injury include "hard signs" (such as pulsatile bleeding, increasing hematoma, pulse deficits, distal ischemia, and thrill/bruit due to AVFs) and "soft signs" (such as proximity of the injury to a major artery, stable hematoma, hypotension, and neurological deficit) (5). Physical and ultrasound examinations after trauma to the extremity are reliable means of detecting an occult arterial lesion. Available imaging modalities include conventional angiography (CA), Doppler ultrasound, computed tomography angiography (CTA) and magnetic resonance angiography (MRA). Digital subtraction angiography is considered the gold standard; however, it is invasive benign procedure and not readily available (6–9). The procedure may be time-consuming, delay definitive treatment, and may lead to complications including general contrast toxicity and pseudoaneurysm formation (6–10).

With recent advances in MDCT allowing routine acquisition of sub-millimeter isotropic data sets, CT angiography (CTA) has become a noninvasive alternative to DSA. Combined with standard post-processing techniques, CTA becomes rapid, accurate noninvasive tool for evaluation of the upper extremity arterial vasculature (11). The aim of this study was to evaluate the role of CTA in evaluation of neglected vascular injuries of the upper extremity following trauma in order to identify the presence of lesion, its nature and exact site.

2. Subjects and methods

This prospective study was conducted during the period between June 2012 and December 2014 and included 20 patients with assumed neglected vascular injury in the upper extremity as a consequence of previous trauma. Written consent was obtained from all patients and approval of the medical ethics committee was obtained. All patients were subjected to full history about type of trauma, immediate vascular, orthopedics, neurological or visceral injury. The methods of management of the trauma, appearance of any early complication and hospitalization period were also included. The period between trauma and the emergence of new symptoms was also noted.

Inclusion criteria:

- Any patient with suspected neglected vascular injury in the upper extremity as a sequel of previous trauma.

Exclusion criteria:

- Patients with contraindication for contrast media injection were excluded from the study.

2.1. CTA technique

The selected 20 patients underwent 64-slice MDCT angiography (CT Light speed, GE Healthcare). Circulation time was determined with a timed bolus of 15 ml of omnipaque 350 mg Iodine/ml (Iohexol, GE health care Ireland, Cork, Ireland) and region of interest was placed at the aortic arch. Contrast enhancement was achieved using a bolus of 80 ml of omnipaque 350 mg followed by 40 ml of normal saline injected at 5 ml/s using a 18 gauche cannula at the anticubital fossa in the contralateral extremity. CTA was acquired with detector collimation of 64 · 0.625 mm at 0.625-mm increments and with a gantry rotation time of 0.35 s. The patients were positioned supine, or rolled into posterior oblique (modified swimmers) position with the non-examined arm raised over the head and positioned near the gantry isocenter. Tape was used to immobilize the forearm, and the fingers were spread and taped in a comfortable position to minimize motion artifact.

2.2. Interpretation of CTA

All data were transferred to dedicated workstation (AW 4.6, GE Healthcare). Curved multiplanar reformations (MPR), volume rendered (VR), and maximum intensity projection (MIP) reconstructions were performed interactively. Images were reviewed independently by the radiologists with 10 experiences in CT angiography (CTA) reading. The agreement on the CTA findings was 95% between the two radiologists. In particular, the reading by the two examiners was coincident in 19 of the 20 patients. In this 1 patient, the final diagnosis was agreed after conjoint re-evaluation of the processed images. Any abnormality was documented and compared with the operative finding.

2.3. Surgical management

Surgical management was performed for all patients once vascular injury was diagnosed by CT angiography using open surgical technique, in form of direct artery repair or interposition grafts.

3. Results

The study included 20 patients, they were 15 males (75%) and five females (25%) with male to female ratio 3:1, and their age ranged between 17 and 47 years (mean 23 ± 6 years). Time delay between trauma and the recent presentation ranged from 5 days to 3 years.

The patients presented with localized swelling, sign of distal ischemia and/or pain (Table 1). Selected patients had history

Table 1 Clinical presentation of the 20 patients.

Presentation	Number (%)
Localized swelling	
Pulsatile	3 (15%)
Non pulsatile	1 (5%)
Distal ischemia	
Rest pain	0
Intermittent claudication	0
Coldness of limb	1 (5%)
Pain	0
Redness and hotness	0

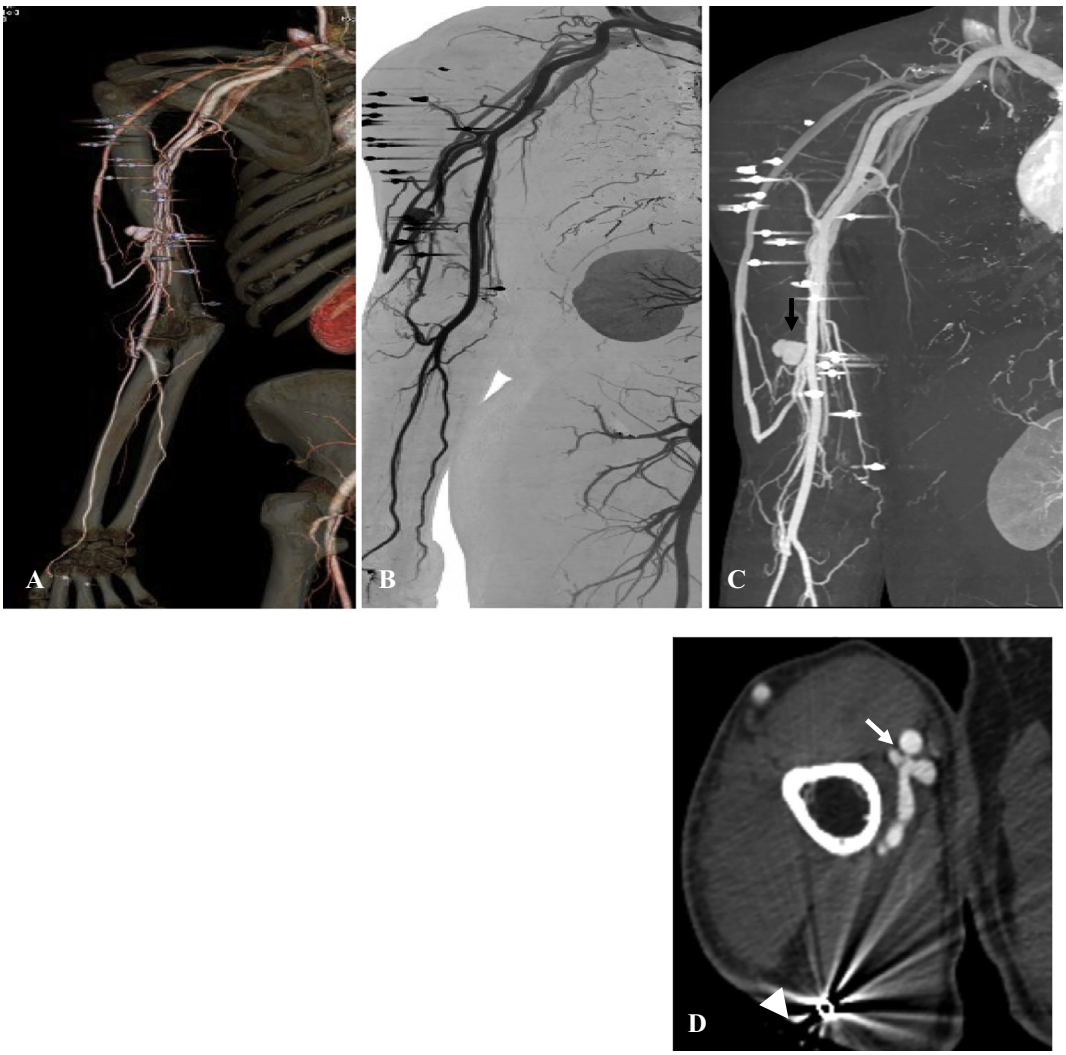

Fig. 1 Twenty-three year old male patient with AVF post gunshot injury. VR CTA (A), curved MPR (B, C), axial cuts CTA (D) reveal axillary artery AVF fistula (proved at surgery to be at the brachial artery level "arrow in D") with pseudo aneurysm at the brachial artery level (arrow in C) as well as distal occlusion at the level of the hand. Multiple subcutaneous pellets of previous gunshot causing metallic artifacts (arrow head in D).

of blunt trauma in 12 patients (motor vehicle or cycle accident 6 cases, fall from height 4 cases and direct blow 2 cases), gunshot in 6 patients and stab in 2 patients, and the blunt trauma injury was the most encountered cause in our patients (60%). Satisfactory results were obtained from CTA in 19 (95%) patients, and only in one patient (5%) metallic artifact from previous gun shots masks the true location of the AVF fistula, as the CTA depicts the AVF fistula at the axillary artery level while it was at the brachial artery level at the operation [Fig. 1].

In the 19 cases (95%) CTA was able to diagnose the presence of vascular injury while it misdiagnose the site in one patient due to metallic artifact, and the lesions were extravascular contrast material-containing collection connected to arterial wall (pseudoaneurysm) in 11 (55%) patients [Figs. 1, 2 and 5], vessel narrowing or stenosis in 5 (25%) patients, occlusion of an arterial segment in 2 (10%) patients (Figs. 3 and 4) and early venous opacification with abnormal change in vessel caliber, contour, or course AVF in 2 (10%) patients (Fig. 1), [Table 2].

The site of injury obtained surgery was subclavian artery in 6 patients (30%, Fig. 5), axillary artery in 8 patients (40%, Figs. 2 and 4) and brachial artery in 6 patients (30%, Figs. 1 and 3) [Table 3].

Surgery was performed for all patients depending on CTA findings, and all patients had opened surgical technique in the form of interposition grafts in 15 patients and 5 patients treated by direct repair of the artery.

Correlation of the site of the lesion with its type was diagnosed by CTA and that during surgery in 20 patients, CTA had 95% sensitivity and 100% specificity.

4. Discussion

Eighty percent of all cases of vascular trauma were attributed to peripheral injuries (12). Upper extremity arterial injuries are often less encountered than those affecting the lower extremity vasculature. Imaging of the upper extremity arterial system is

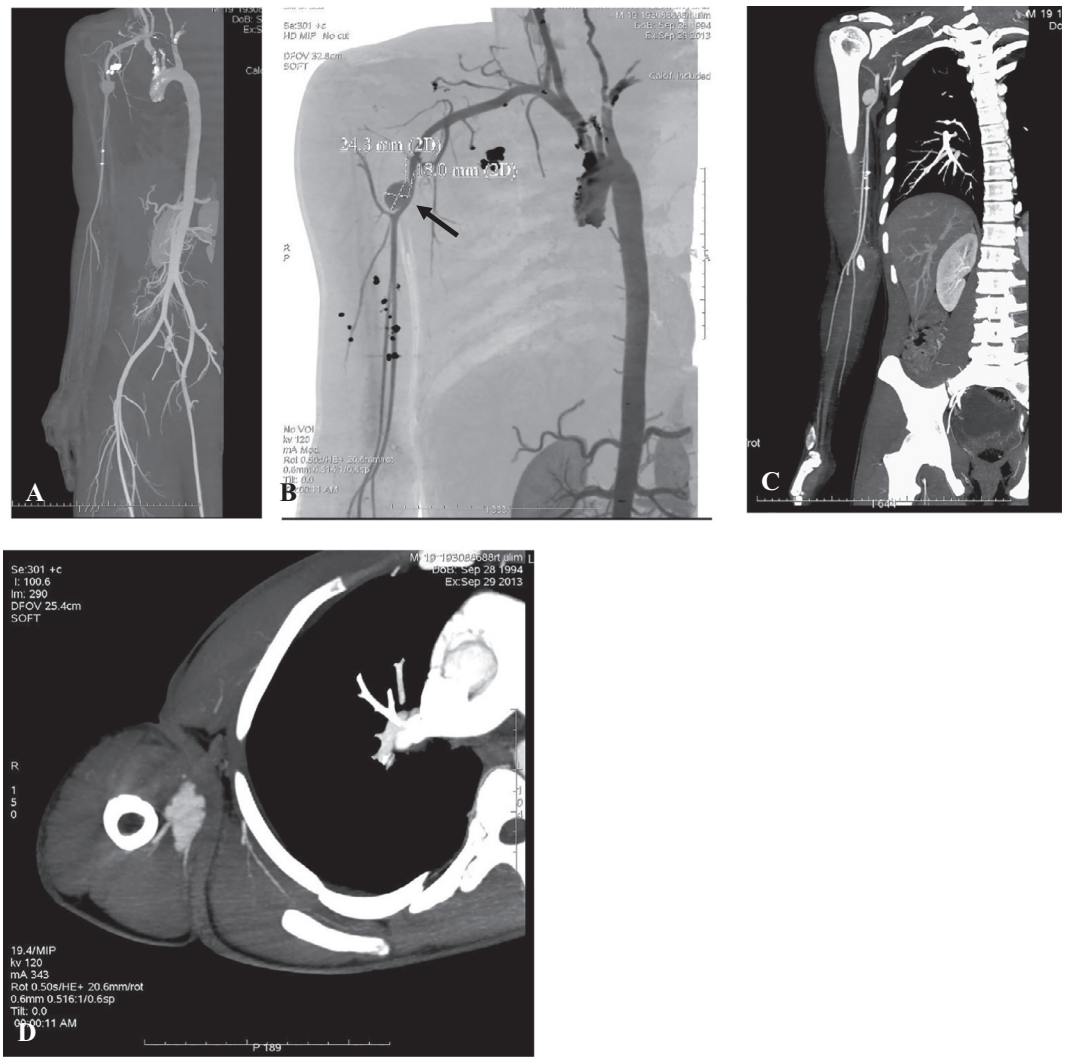

Fig. 2 Twenty-one year old male patient with axillary artery pseudo aneurysm post gunshot injury. Curved MPR (A, B, C), axial cuts CTA (D) reveal axillary artery pseudo aneurysm (arrow in B) as well as distal occlusion of the radial and ulnar arteries.

usually performed in trauma patients, patients with ischemic symptoms of the upper extremities, for preoperative planning of complex upper extremity vascular reconstructions and dialysis access, and for evaluation of post endovascular surgical procedures (13). Computed tomography angiography (CTA) has been shown to be precise for detecting vascular injuries of the extremities in patients with penetrating trauma, with extensive data published on the evaluation of extremity vascular lesions (14–17).

The aim of this study was to evaluate the role of CTA in evaluation of patients with missed vascular injury of the upper extremity following trauma in order to identify the presence of lesion, its nature and exact site.

The cause of the vascular injury in the current study was history of blunt trauma in 60% of the patients, gunshot in 30% of the patients and stab in 10% of the patients, and the blunt trauma injury was the most encountered cause in our patients. Different literatures vary in the incidence of the causes, in some studies penetrating trauma represents 45.8% (18) and in another one accounts for 70–90% of vascular injuries (19). However, blunt trauma was predominant in different series (20).

As our study deals only with those patients having occult vascular injuries due to old trauma, none of the study group patients had hard signs of vascular injury at the time of initial presentation, in agreement with the study by Yilmaz et al. (5) who reported none of their study group patients with similar inclusion criteria to present study had ''hard'' signs of vascular injury at the time of initial hospitalization.

Conventional angiography (CA) is considered the gold standard imaging modality in diagnosing vascular injury in the setting of trauma; however, CA is an invasive procedure (11, 14–16). It can be used for intervention at the same setting for some types of injury e.g. angioplasty for stenosis and coiling for aneurysm (21).

Nowadays CTA is considered suitable substitute and becomes the diagnostic modality of choice in evaluation of extremity vascular injury. With recent advances in MDCT allowing routine acquisition of sub millimeter isotropic data sets, CT angiography (CTA) has become a noninvasive

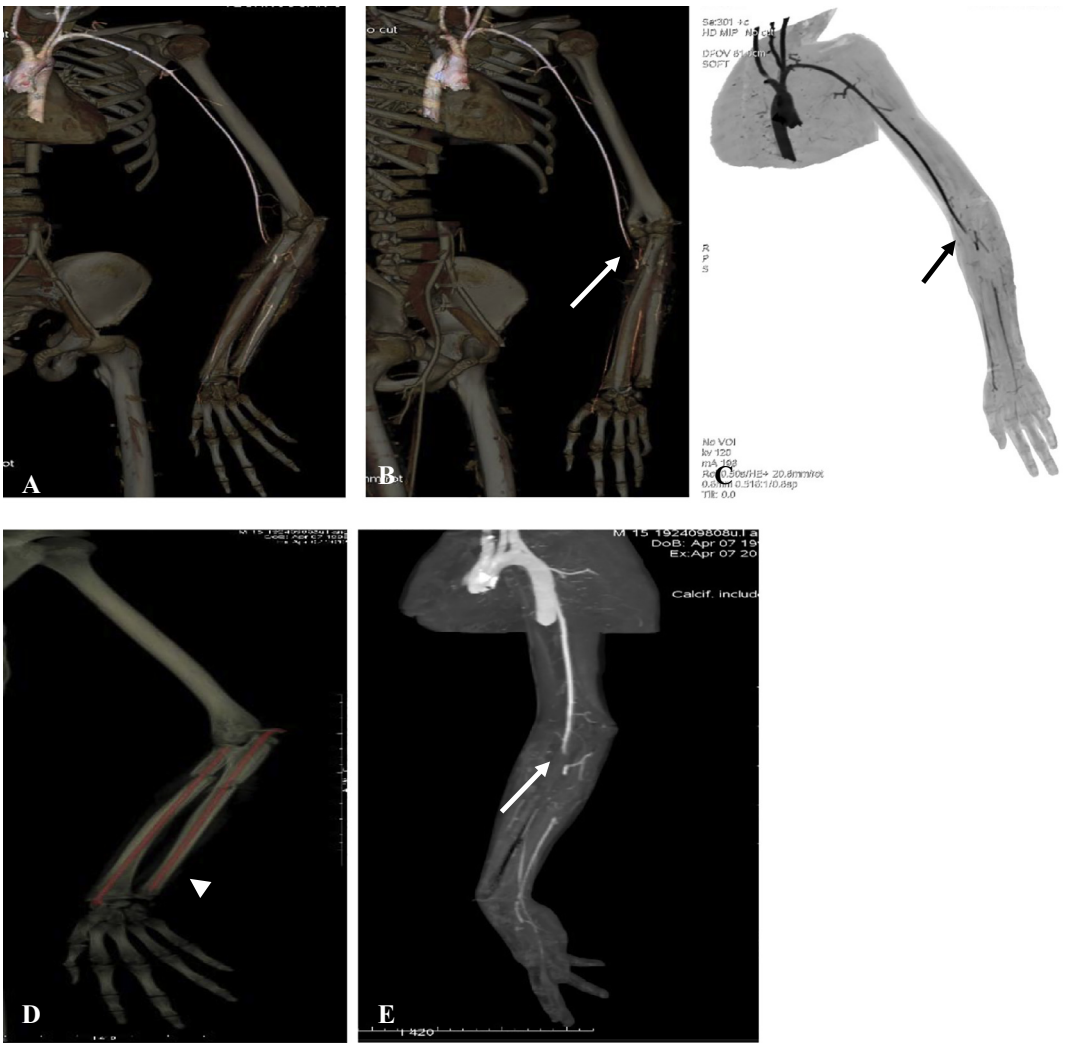

Fig. 3 Twenty year old male patient with total occlusion of the brachial artery (arrow in B, C, E) following proximal third both shaft of the radius and ulna. VR CTA (A, B, D), Curved MPR (C, E), reveal total occlusion of the brachial artery proved at surgery to be total occlusion. Nail fixation of fracture proximal third both shaft of the radius and ulna (arrow head in D).

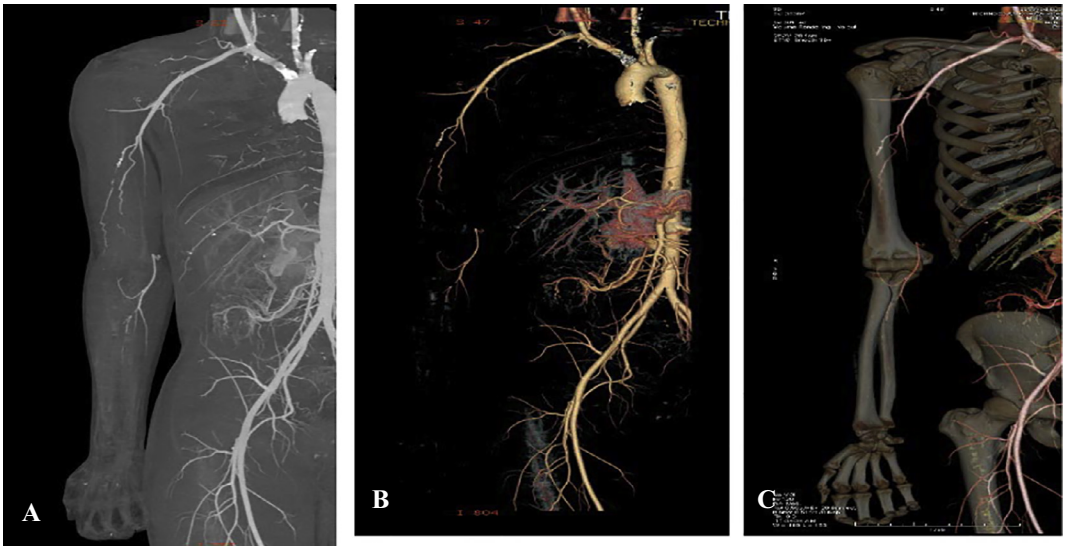

Fig. 4 Nineteen year old male patient with total occlusion of the axillary artery following blunt trauma. Curved MPR (A), VR CTA (B, C), reveal total occlusion of the axillary artery with multiple collaterals and no reformation as well as distal ischemia.

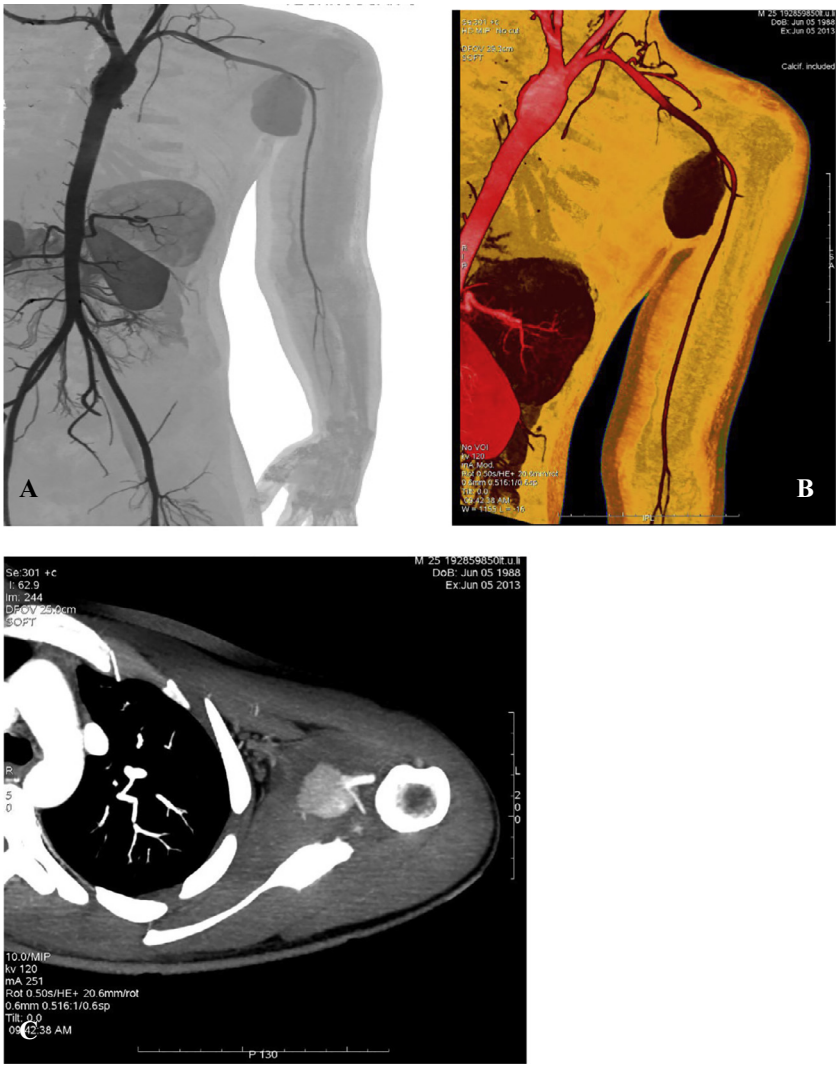

Fig. 5 Twenty-five year old male patient with pseudoaneurysm following blunt trauma. Curved MPR (A), VR CTA (B), axial CTA (C) reveal distal subclavian artery pseudoaneurysm with distal ischemia.

Table 2 Types of vascular injuries depicted by CTA.

Type of the injury	Number of patients	%
Pseudo aneurysm	11	55
Stenosis	5	25
Occlusion	2	10
AVF	2	10

Table 3 Site of the vascular injury depicted by CTA in comparison with surgical findings.

Site	CTA	Surgery
Subclavian artery	6 (30%)[a]	5 (25%)
Axillary artery	8 (40%)	8 (40%)
Brachial artery	6 (30%)	7 (35%)

[a] CTA missed the true location in that case because of metallic artifacts.

alternative to DSA. Combined with standard post processing techniques, CTA is rapid, accurate noninvasive modality in evaluation of the upper extremity arterial vasculature (11,22).

In the present study, CTA detects the vascular complications as pseudo aneurysms in 11 patients (55%), stenosis in 5 patients (25%), total occlusion in 2 patients (10%) and AVF in 2 patients (10%) in agreement with (23) who described those lesions as late complications of missed arterial injuries. The frequency of occurrence is varied, and Escobar et al. (24) reported false aneurysms (38.5%) and arterial insufficiency (24.5%) secondary to AVF accounting for the majority of missed arterial injuries. In the studies by Yilmaz et al. and Fatma et al. (11,22), there were 52.5% pseudo aneurysms, and 12.5% arterial occlusion but they reported high rate of 35% for A-V fistulae.

The aggressive nature of these injuries, due to violent forces, and the associated muscle trauma and edema, all participate in the development of tissue edema that may progress to compartment syndrome that may seriously jeopardize a successful arterial reconstruction (25). We thought that the development of ischemia and arterial occlusion in the present study was due to the development of edema.

The site of injury in the present study obtained at surgery showed that the axillary artery in was the common affected artery (40%) and followed the brachial and subclavian arteries (30% for each) in agreement with Jonathan et al. (26) who mentioned that traumatic injuries to the axillary and brachial arteries remain rare, representing 15–20% of arterial injuries to the upper limb.

High sensitivity and specificity of CTA in detecting suspected vascular injuries of the extremities were described, in many studies ranging from 95% to 100% and 90–100%, respectively (22,27) in agreement with our results that showed sensitivity (95%) and specificity (100%) achieved by CTA.

In this series all clinically suspected injuries were detected by CTA except one case with metallic artifact (5%) with misdiagnosed site of the injury. All injuries were approved at time of operation and surgically repaired. Series published to date, reported that artifacts arising from metallic objects existing adjacent to the examined arteries can limit evaluation of the arterial segments or even the entire examination (28). Limitations of this study were small sample size that may affect the results, but this may be related to lower incidence of neglected trauma in the upper extremity.

5. Conclusion

MDCT angiography is highly accurate initial noninvasive diagnostic tool for the evaluation of vascular abnormalities of the upper extremity arterial system in patients with suspected neglected extremity trauma. Limitation of CTA examination was the presence of metallic artifact adjacent to the examined arteries.

Conflict of interest

None.

Acknowledgment

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